

# PERFORMANCE OF PINEAPPLE LEAF FIBRE AS REINFORCEMENT IN OIL PALM SHELL LIGHTWEIGHT CONCRETE

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## **STUDENT'S DECLARATION**

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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PERFORMANCE OF PINEAPPLE LEAF FIBRE  
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## ABSTRAK

Konkrit dibentuk oleh agregat kasar yang tertanam dalam matriks simen yang mengisi ruang dan lompong di antara zarah agregat dan melekatkannya bersama-sama. Dalam eksperimen ini, konkrit ringan, yang lebih mampan alam sekitar dibandingkan dengan konkrit konvensional, yang menggunakan sepenuhnya simen. Konkrit ringan lebih mampan alam berbanding dengan konkrit konvensional kerana konkrit ringan mengurangkan penggunaan simen serta kuantiti agregat yang menyebabkan kemusnahan bukit menyebabkan ketidakseimbangan geologi dan alam sekitar. Konkrit konvensional adalah bahan rapuh di mana retakan struktur akan dikembangkan walaupun sebelum beban digunakan kerana kekuatan tegangan yang rendah, kemuluran terhad, dan sedikit ketahanan terhadap retak. Beban luaran akan menyebabkan penyebaran lebih banyak keretakan yang sedia ada dan akhirnya menyebabkan keretakan konkrit dan keretakan tambahan yang baru terbentuk. Oleh itu, kemasukan tetulang dalam konkrit adalah diperlukan. Gentian biasanya digunakan dalam konkrit untuk mengawal penyebaran retakan mikro, pengecutan dan untuk meningkatkan kekuatan dan prestasi konkrit. Dalam penyelidikan yang lalu, kerana pertimbangan ancaman terhadap alam sekitar, serat mesra alam diperkenalkan kepada bidang konkrit sebagai sumber alternatif serat yang akan digunakan dalam konkrit untuk meningkatkan sifat mekaniknya. Kajian utama ini adalah untuk menumpukan kepada kelakuan mekanikal serat daun nanas (PALF) dalam konkrit ringan sawit kelapa sawit dalam pecahan volum serat yang berbeza kepada jumlah konkrit 0.5 %, 1 %, 1.5 % dan 2.0 % daripada PALF berbanding dengan konkrit biasa . PALF diekstrak dan kemudian dirawat dengan natrium hidroksida dengan kepekatan 10% untuk meningkatkan ketahanan serat. Dalam kajian ini, panjang PALF dibuat berterusan sebanyak 40mm berdasarkan panjang gentian optimum dari penyiasatan sebelumnya. Ujian eksperimen dalam kerja ini termasuk ujian kemerosotan, ujian kiub, ujian lenturan empat mata dan ujian tegasan pemisahan yang terdiri daripada 60 kiub, 15 rasuk dan 15 silinder. Kubis konkrit diuji pada umur sembuh 3, 7, 14 dan 28 hari, manakala bagi silinder dan rasuk hanya perlu diuji pada 28d. Proses pengawetan air yang berterusan telah dijalankan untuk semua kiub, silinder dan sampel rasuk untuk tempoh yang diperlukan. Dari pelbagai hasil ujian, prestasi konkrit biasa dan sifat konkrit ringan dan mekanikal gentian konkrit bertetulang serat minyak kelapa sawit telah disahkan. Penyelidikan menunjukkan bahawa kekuatan mampatan menurun pada semua peringkat umur dengan peningkatan pecahan pecutan PALF, manakala kekuatan tegangan dan kekuatan lenturan yang berpecah memberikan hasil yang positif dengan sedikit penambahan serat. Kemasukan PALF meningkatkan kekuatan tegangan dan lenturan sehingga 3.28 MPa dan 6.55 MPa masing-masing. Berbanding dengan campuran kawalan 0 %, apabila serat meningkat kepada 1 %, kekuatan lenturan dan kekuatan tegangan meningkat sehingga 36.32 %. Dari hasil yang diperolehi, 1.0 % PALF adalah nisbah volum serat optimum untuk pembangunan kekuatan tegangan dan lentur. Dari segi kebolehmampuan, penambahan PALF dalam campuran konkrit secara drastik menurunkan kebolehkkerjaan konkrit yang baru dicampur dengan air serat yang diserap. Oleh itu, dapat disimpulkan bahawa PALF sesuai untuk digunakan dalam konkrit ringan, namun tidak sesuai untuk menghasilkan konkrit ringan yang tinggi.

## ABSTRACT

Concrete is formed by coarse aggregate embedded in the cement matrix which fills the spaces and voids among the aggregate's particles and glue them together. In this experiment, lightweight concrete, which is more environmentally sustainable as compared to conventional concrete, which fully using cement was studied. Lightweight concrete is more environmentally sustainable as compared to conventional concrete because lightweight concrete reduces usage of cement as well as quantities of aggregates which results in destruction of hills causing geological and environmental imbalance. Conventional concrete is relatively a brittle material where the structural cracks will be developed even before loadings are applied due to its low tensile strength, limited ductility, and little resistance towards cracking. The external load will lead to further propagation of existing cracks and eventually caused spalling of concrete and the newly formed additional cracks. Hence, inclusion of reinforcement in concrete is necessary. Fibres are commonly used in concrete to control the propagation of micro cracks, shrinkage and to improve the strength and performance of concrete. In the past researches, due to consideration of threat to the environment, eco-friendly fibre is introduced to the field of concrete as an alternative source of fibre to be used in concrete for increasing its mechanical properties. The highlight of this research is to focus on the mechanical behaviour of pineapple leaf fibre (PALF) in oil palm shell lightweight concrete in different fibre volume fractions to concrete volume 0.5%, 1.0%, 1.5% and 2.0% of PALF compared to plain concrete. PALF was extracted and then treated with sodium hydroxide with concentration of 10% to enhance fibres durability. In this research, the length of PALF was made constant as 40 mm based on optimum fibre length from previous investigations. The experimental testing in this work include slump test, cube test, four-point bending test and splitting tensile test which comprises of 60 cubes, 15 beams and 15 cylinders. The concrete cubes were tested at the curing age of 3, 7, 14 and 28 days, whereas for cylinder and beam were tested at 28 days. Continuous water curing process was conducted for all cubes, cylinders and beams samples for the required period. From the various test results, the performance of plain concrete and lightweight concrete and mechanical properties of fibre reinforced oil palm shell lightweight concrete were evaluated. The research showed that the compressive strength decreased at all ages with an increase in PALF volume fraction, whereas splitting tensile strength and flexural strength give positive result those with a small amount of fibre addition. The inclusion of PALF increase the tensile and flexural strength up to 3.28 MPa and 6.55 MPa respectively. Compared to the control mix 0%, when the fibre increase to 1.0%, the flexural strength and tensile strength increase up to 36.32%. From the results obtained, 1.0% PALF is the optimum fibre volume ratio for tensile and flexural strength development. In terms of workability, the addition of PALF in concrete mix drastically decreased the workability of freshly mixed concrete as the fibre absorbed water greatly. Hence, it can be concluded that PALF is suitable to be used in lightweight concrete, however not suitable to produce high strength lightweight concrete.

## **TABLE OF CONTENT**

**DECLARATION**

**TITLE PAGE**

**ACKNOWLEDGEMENTS** **ii**

**ABSTRAK** **iii**

**ABSTRACT** **iv**

**TABLE OF CONTENT** **v**

**LIST OF TABLES** **ix**

**LIST OF FIGURES** **x**

**LIST OF SYMBOLS** **xii**

**LIST OF ABBREVIATIONS** **xiii**

**CHAPTER 1 INTRODUCTION** **1**

**1.1 Research Background** **1**

**1.2 Problem Statement** **2**

**1.3 Research Objectives** **3**

**1.4 Scope of Research** **3**

**1.5 Research Significance** **4**

**CHAPTER 2 LITERATURE REVIEW** **6**

**2.1 Background** **6**

**2.2 Oil Palm Shell Lightweight Concrete** **7**

**2.3 Pineapple Leaf Fibre** **8**

2.3.1 Chemical Properties of Pineapple Leaf Fibre **10**

2.3.2	Physical/Mechanical Properties of Pineapple Leaf Fibre	11
2.3.3	Structural Behaviours of Pineapple Leaf Fibre in Concrete	13
<b>2.4</b>	<b>Factor Affecting Mechanical Properties of Pineapple Leaf Fibre Reinforced</b>	<b>17</b>
2.4.1	Mechanical Properties Affected by Fibre Content	17
2.4.2	Mechanical Properties Affected by Fibre Treatment	18
2.4.3	Mechanical Properties Affected by Fibre Surface	19
2.4.4	Mechanical Properties Affected by Mixing and Placing	19
2.4.5	Challenges for Pineapple Leaf Fibre as Reinforcement	20
<b>2.5</b>	<b>Pineapple Leaf Fibre Extraction method</b>	<b>21</b>
2.5.1	Manual Extraction Method	22
2.5.2	Mechanical Extraction Method	23
<b>2.6</b>	<b>Pineapple Leaf Fibre Length</b>	<b>24</b>
2.6.1	Fibre Aspect Ratio	25
2.6.2	Fibre Optimum Length	26
<b>2.7</b>	<b>Fibre Fraction to Concrete Volume Ratio</b>	<b>28</b>
<b>2.8</b>	<b>Physical Properties Test</b>	<b>29</b>
2.8.1	Slump Test (fresh properties)	29
<b>2.9</b>	<b>Mechanical Properties Test</b>	<b>31</b>
2.9.1	Cube Test	31
2.9.2	Four-Point Bending Test	32
2.9.3	Splitting Tensile Test	34
<b>2.10</b>	<b>Summary</b>	<b>36</b>
<b>CHAPTER 3</b>	<b>METHODOLOGY</b>	<b>37</b>
<b>3.1</b>	<b>Introduction</b>	<b>37</b>



<b>3.2</b>	<b>Pineapple Leaf Fibre Preparation</b>	<b>40</b>
3.2.1	Treatment of Pineapple Leaf Fibres	40
3.2.2	Pineapple Leaf Fibre Optimum Aspect Ratio Determination	40
3.2.3	Pineapple Leaf Fibre Diameter Determination	40
3.2.4	Pineapple Leaf Fibre Length Determination	41
3.2.5	Cutting of Pineapple Leaf Fibre	43
<b>3.3</b>	<b>Material Preparation</b>	<b>43</b>
3.3.1	Oil Palm Shell (OPS)	43
3.3.2	Ordinary Portland Cement (OPC)	45
3.3.3	River Sand	46
3.3.4	Water Content	46
3.3.5	Mineral Admixture	46
3.3.6	Super plasticizer (SP)	46
<b>3.4</b>	<b>Specimens Preparation</b>	<b>47</b>
3.4.1	Number and Size of Specimens Used	47
3.4.2	Concrete Mixing Procedure	48
3.4.3	Curing Process	49
<b>3.5</b>	<b>Cube Test</b>	<b>49</b>
<b>3.6</b>	<b>Four-Point Bending Test</b>	<b>50</b>
<b>3.7</b>	<b>Splitting Tensile Test</b>	<b>52</b>
<b>CHAPTER 4 RESULT AND DISCUSSION</b>		<b>54</b>
<b>4.1</b>	<b>Introduction</b>	<b>54</b>
<b>4.2</b>	<b>Slump Test</b>	<b>54</b>
<b>4.3</b>	<b>Hardened Density</b>	<b>56</b>
<b>4.4</b>	<b>Compression Test</b>	<b>58</b>

4.4.1	Factors that affect reduction in concrete compressive strength	61
4.4.2	Cube Failure Mode	63
<b>4.5</b>	<b>Splitting Tensile Test</b>	<b>64</b>
4.5.1	Column Failure Mode	67
<b>4.6</b>	<b>Flexural Test</b>	<b>68</b>
4.6.1	Beam Failure Mode	69
 <b>CHAPTER 5 CONCLUSION AND RECOMMENDATION</b>		
<b>4.7</b>	<b>Introduction</b>	<b>72</b>
<b>4.8</b>	<b>Conclusion</b>	<b>72</b>
<b>4.9</b>	<b>Recommendation</b>	<b>73</b>
<b>REFERENCES</b>		<b>74</b>
<b>APPENDIX A</b>		<b>78</b>
<b>APPENDIX B</b>		<b>79</b>
<b>APPENDIX C</b>		<b>80</b>
<b>APPENDIX D</b>		<b>81</b>

## LIST OF TABLES

Table 2.1	Chemical composition of PALF	11
Table 2.2	Physical and mechanical strength of PALF	12
Table 2.3	Comparison of mechanical properties of PALF and other fibre	12
Table 2.4	Comparison between conventional reinforced concrete and fibre reinforced concrete	16
Table 2.5	Factors affecting properties of natural fibre reinforced concrete	17
Table 2.6	Impact of fibre treatment on the mechanical properties of PALF/Polyester composite	19
Table 2.7	Tensile properties of untreated and treated PALF	20
Table 2.8	Flexural strength of concrete prisms	34
Table 3.1	Result of tensile strength test of various fraction PLF/Epoxy and various fibres length	42
Table 3.2	Result of bending test of various fibres fraction and fibres length	42
Table 3.3	Properties of hardened OPS concrete at 28 days	44
Table 3.4	Number of cubes, cylinders and beams specimens	47
Table 3.5	Dimension of cube, beam and cylinder specimens	48
Table 3.6	Concrete mix design for lightweight concrete	48
Table 4.1	Slump test result	55
Table 4.2	Oven-dry and demoulded density of OPS concrete.	57
Table 4.3	Development of compressive strength of cube specimens with variable PALF volume fraction.	58
Table 4.4	Minimum compressive strength required by Standard Specification for Lightweight Aggregates for Structural Concrete (ASTM C330) Test Method C 39/C 39M	60
Table 4.5	Comparison between standard minimum compressive strength and compressive strength that obtained from experiment.	60
Table 4.6	Development of splitting tensile strength of cylinder specimens with variable PALF volume fraction.	64
Table 4.7	Relationship between splitting tensile strength to compressive strength ratio and PALF volume fraction	66
Table 4.8	Development of flexural strength of beam specimens with variable PALF volume fraction	68

## LIST OF FIGURES

Figure 2.1	Classification of natural fibre	8
Figure 2.2	Production, export, and area trends of pineapple Industry in Malaysia, 1975–2015	9
Figure 2.3	Average share pineapple production by region in 2005-2014	10
Figure 2.4	Anatomical structure and morphology of PALF	13
Figure 2.5	Post-cracking performance of FRC	15
Figure 2.6	Tensile modulus of PALF/Polyester composite	18
Figure 2.7	Production process of PALF	22
Figure 2.8	Manual extraction of PALF	23
Figure 2.9	Mechanical extraction of PALF	24
Figure 2.10	Illustration about 2 types of fibre aspect ratio.	25
Figure 2.11	The deformation pattern in matrix surrounding a fibre that is subjected to an applied tensile load.	26
Figure 2.12	Stress profiles when the fibres length	27
Figure 2.13	Mechanism of failure of concrete cylinder under splitting tensile test	28
Figure 2.14	Workability of OPSFRC versus volume fraction	30
Figure 2.15	Types of concrete slump	31
Figure 2.16	28 days compressive strength of PALFLWC versus volume fraction	32
Figure 2.17	Set up of four-point bending test	33
Figure 2.18	Splitting tensile test model	35
Figure 2.19	Internal strengthening of fibre reinforced concrete	35
Figure 2.20	28 days tensile strength result versus PALF loading	36
Figure 3.1	Research flow chart	38
Figure 3.2	Procedure of laboratory work.	39
Figure 3.3	Electronic digital calliper	41
Figure 3.4	Cut-in-size PALF	43
Figure 3.5	Air-dried of OPS after soaking for 24 hours	45
Figure 3.6	YTL ORANG KUAT Ordinary Portland Cement	45
Figure 3.7	Curing of specimens	49
Figure 3.8	a) Cube specimen compression test b) Cube test machine	50
Figure 3.9	Four-point bending machine	51
Figure 3.10	a) Cylinder splitting tensile test b) Cylinder test machine	53

Figure 3.11	Dimension of cylinder specimen and imposed loads	53
Figure 4.1	Effect of PALF volume fraction on concrete slump	55
Figure 4.2	Slump test for (a) PALF reinforced mix (b) control mix	56
Figure 4.3	Effect of PALF volume fraction on concrete hardened density	57
Figure 4.4	Effect of PALF volume fraction and curing duration on concrete compressive strength	59
Figure 4.5	Cube failure pattern	63
Figure 4.6	Effect of PALF volume fraction on splitting tensile strength.	65
Figure 4.7	Relationship between splitting tensile strength to compressive strength ratio and PALF volume fraction	66
Figure 4.8	Column failure pattern	67
Figure 4.9	Effect of PALF volume fraction on flexural strength.	69
Figure 4.10	Failure mode of plain concrete beam	70
Figure 4.11	Failure mode of 2.0% PALF reinforced concrete beam	71
Figure 4.12	PALF bridging inside the concrete	71

## LIST OF SYMBOLS

%	Percentage
mm	Millimetre
MPa	Mega Pascal
kg	Kilogram
kg/m <sup>3</sup>	Kilogram per cubic metre
N	Newton
°C	Degree Celsius
kN	kilo Newton
kN/s	kilo Newton per second
°C	Degree Celcius

## LIST OF ABBREVIATIONS

PALF	Pineapple leaf fibre
ASTM	American Society for Testing and Materials
FRC	Fibre-reinforced concrete
V <sub>f</sub>	Volume fraction
PALF	Pineapple leaf fibre
OPC	Ordinary Portland Cement
OPSLWC	Oil palm shell lightweight concrete
SSD	Saturated surface dry
UTM	Universal Testing Machine
HSLWC	High strength lightweight concrete
NaOH	Sodium Hydroxide

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Research Background**

Concrete is formed by coarse aggregate embedded in the cement matrix which fills the spaces and voids among the aggregate's particles and glue them together. In this experiment, lightweight concrete which is more environmentally sustainable as compare to conventional concrete which fully using cement is used. Lightweight concrete is more environmentally sustainable as compare to conventional concrete because lightweight concrete reduces usage of cement as well as quantities of aggregates which results in destruction of hills causing geological and environmental imbalance. In this research, the main purpose of investigate lightweight concrete because lightweight concrete has lower strength as compare to conventional concrete, we want to investigate by addition of fibre composite can enhance lightweight concrete strength until which extent.

Plain concrete is a relatively brittle material where the structural cracks will be developed even before loadings are applied due to its low tensile strength, limited ductility, and little resistance towards cracking. The external load will lead to further propagation of existing cracks and eventually caused spalling of concrete and the newly formed additional cracks. Hence, inclusion of reinforcement in concrete is necessary. A French gardener by name Joseph Monier first invented the reinforced concrete in the year 1849. Fibres are commonly used in concrete to control the propagation of micro cracks, shrinkage and to improve the strength and performance of concrete. Portland cement concrete is weak in tension loading while strong in compression loading whereas reinforced concrete is strong in compression loading as well as tension loading.



Therefore, eco-friendly fibre is introduced to the field of concrete to enhance its tensile capacity.

Egyptians has developed the concept of using fibres in the concrete mix as one of a reinforcing materials before they used to mix the straw and hairs of animals in the concrete as a material of reinforcement. (Mahesh and Kavitha, 2016). Natural fibre based composites are under intensive study due to their eco-friendly nature, peculiar properties, huge and wide range availability, easy and safe handling due to their flexibility, and biodegradable nature. From the socioeconomic prospective, PALF can be a new source of raw material to the industries and can be potential replacement of the expensive and non-renewable synthetic fibre.

In the past researches, due to consideration of threat to environment, researchers have used plant fibres as an alternative source of steel and/or artificial fibres to be used in composites (such as cement paste mortar and/or concrete) for increasing its strength properties. (Kavitha & Dr. T Felix 2017) These plant fibres, herein referred as natural fibres, include coir, sisal, jute, pineapple leaf, kenaf, abaca leaf, bamboo, palm, banana, hemp, flax, cotton and sugarcane.

Pineapple leaf fibre (PALF) is one of the fast-growing plants and abundantly available wastes materials of Malaysia as compared to other natural fibre which are less productive. Hence, PALF has gained stimulants as an alternative to substitute synthetic fibres. Their use can lead to sustainable development. Since they are waste material, make use of them can reduce landfill consumption, environmental containment as well as reduce cost to manage them. Synthetic (chemically produced) fabrics are made by joining monomers into polymers, through a process called polymerization. Examples of synthetic fabrics include polyester, acrylic, nylon and rayon. They were costly and have an impact on environment as it is not biodegradable. Rayon is artificial silk that made from wood pulp. The sustainable supply of PALF can reduce the pressure on forest and agriculture.

## **1.2 Problem Statement**

The major disadvantage is that concrete develops micro cracks during curing. It is the rapid propagation of these micro cracks developed in plain concrete easily under applied stress basically due to drying shrinkage. Plain concrete possesses a very low

tensile strength, limited ductility and low resistance towards cracking especially lightweight concrete where its compressive and flexural strengths reduce with its density hence need some reinforcement in it. Concrete in service thus cracks easily and this cracking creates easy access routes for deleterious agents resulting in early saturation, freeze-thaw damage, scaling, discoloration and steel corrosion. To overcome this problem, various types of fibre composites were added into cement matrix to enhance the crack control and also concrete strength. In this research, natural fibre composite is used instead of synthetic fibre as synthetic material which are by-products of petroleum are non-biodegradable, synthetic products take a long time to decompose, creating long-term pollution. Nylon is hard to recycle, making them hard to decompose, accumulate landfills more. Besides, addition of steel fibre in concrete although can reduce micro cracks propagation but steel have high probability to corrode once it exposes to environment causing it to lose bonding capability in concrete.

### **1.3 Research Objectives**

The objectives of the research are as follows:

- i. To determine the physical properties (workability) of OPS lightweight concrete
- ii. To determine the mechanical properties (compression test, flexural test and split tensile test) of OPS lightweight concrete with 0.5%, 1.0 %, 1.5 %, and 2.0 % of pineapple leaf fibre
- iii. To validate the performance of plain concrete and OPS lightweight concrete

### **1.4 Scope of Research**

The highlight of this research is to focus on the mechanical behaviour of PALF in oil palm shell lightweight concrete in different fibre content (fibre volume ratio to concrete volume ratio) as compared to plain concrete. PALF is a product extracted from pineapple leaf which is easily available in the states of Johor, Sarawak, Sabah, Kedah, Selangor, Penang, and Kelantan. These fibres extracted are then treated with sodium hydroxide with the optimum concentration of 10 % to enhance fibre durability. In this research, the length of PALF is made constant based on fibre optimum length to

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